

Measuring Rheological Properties of Cement-Based Materials

Chiara F. Ferraris

John Winpigler

Building and Fire Research Laboratory

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NIST

National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce



Virtual Concrete Rheology

Concrete composition

- Aggregates gradation and shape
- Mineral and chemical admixtures
- Cement type

Rheology

- Paste measurements
- Computer simulation

Prediction

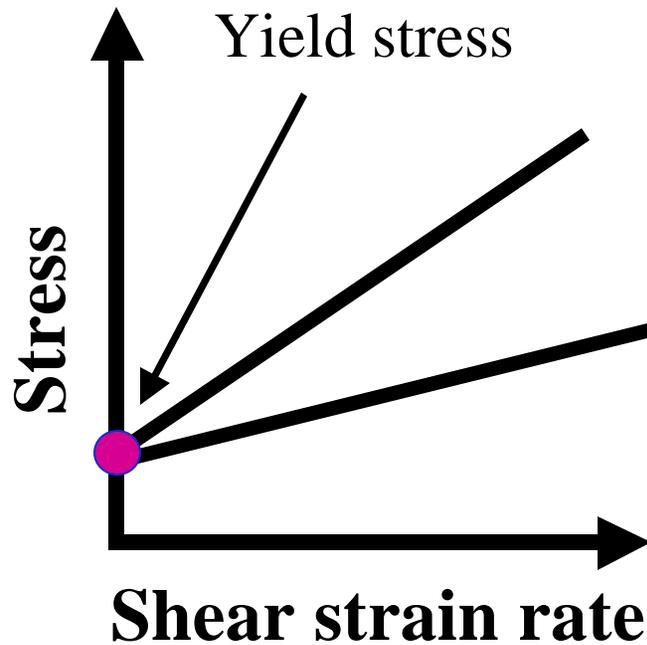
Fresh concrete

- Workability
- Placement
- Finishability

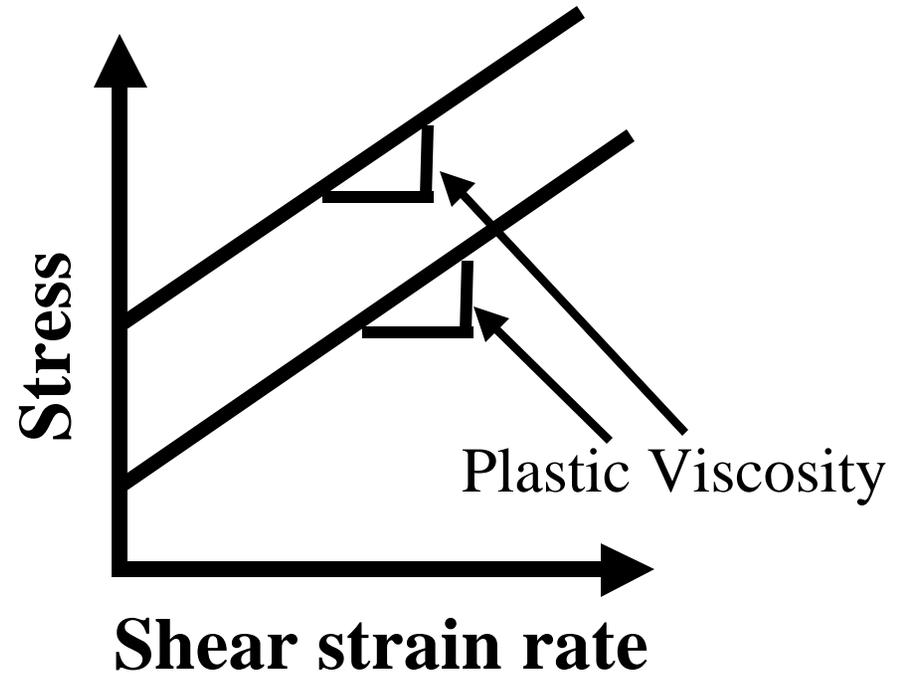
Survey of Field Problems

- **Workability:** Slump test is adequate but a better test is needed
- **Segregation:** not measurable
- **Finishability:** sticky concrete
- **Screening of materials:** costly

Bingham model concept

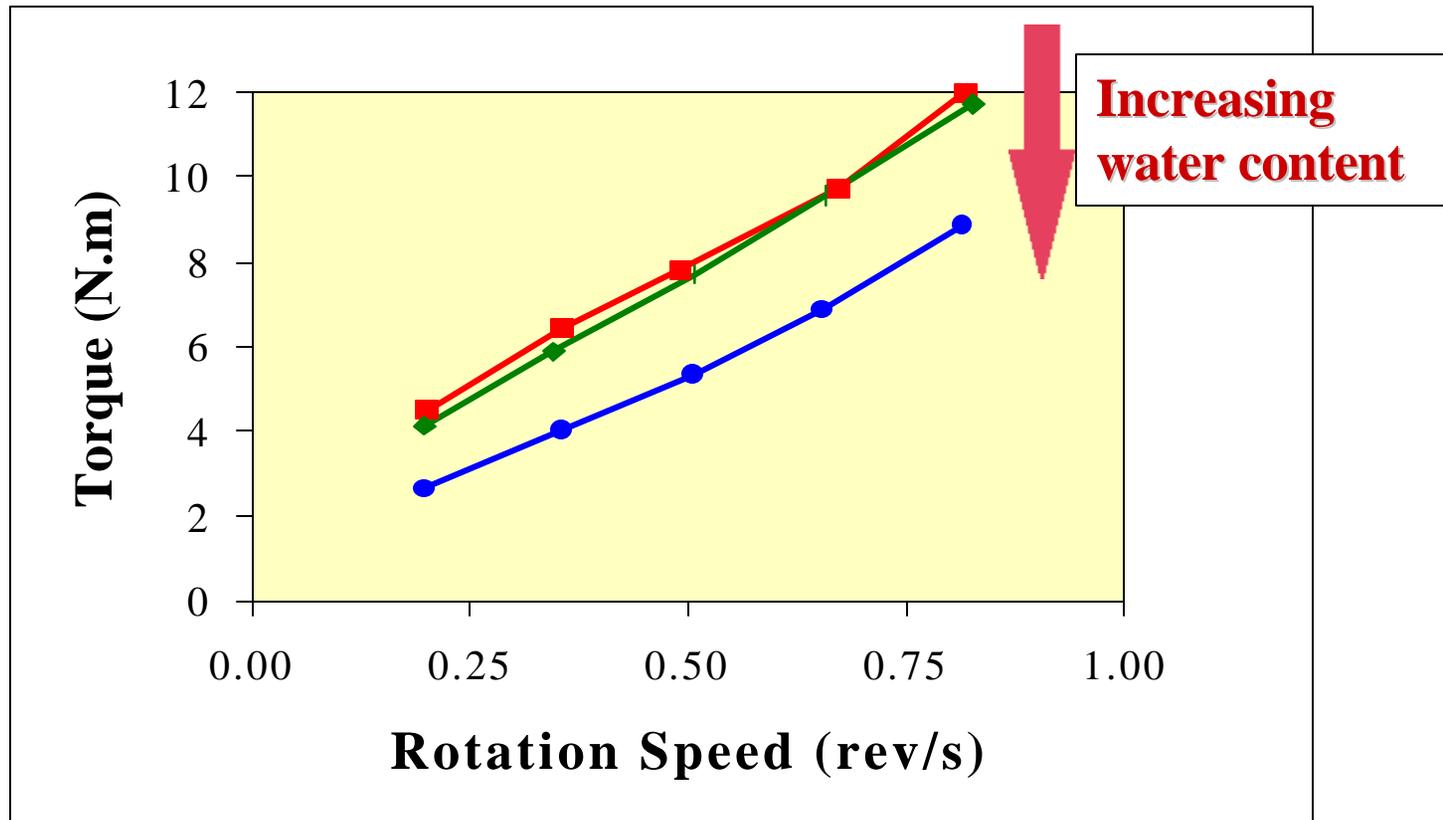


Same Yield Stress
BUT
Different Plastic Viscosity



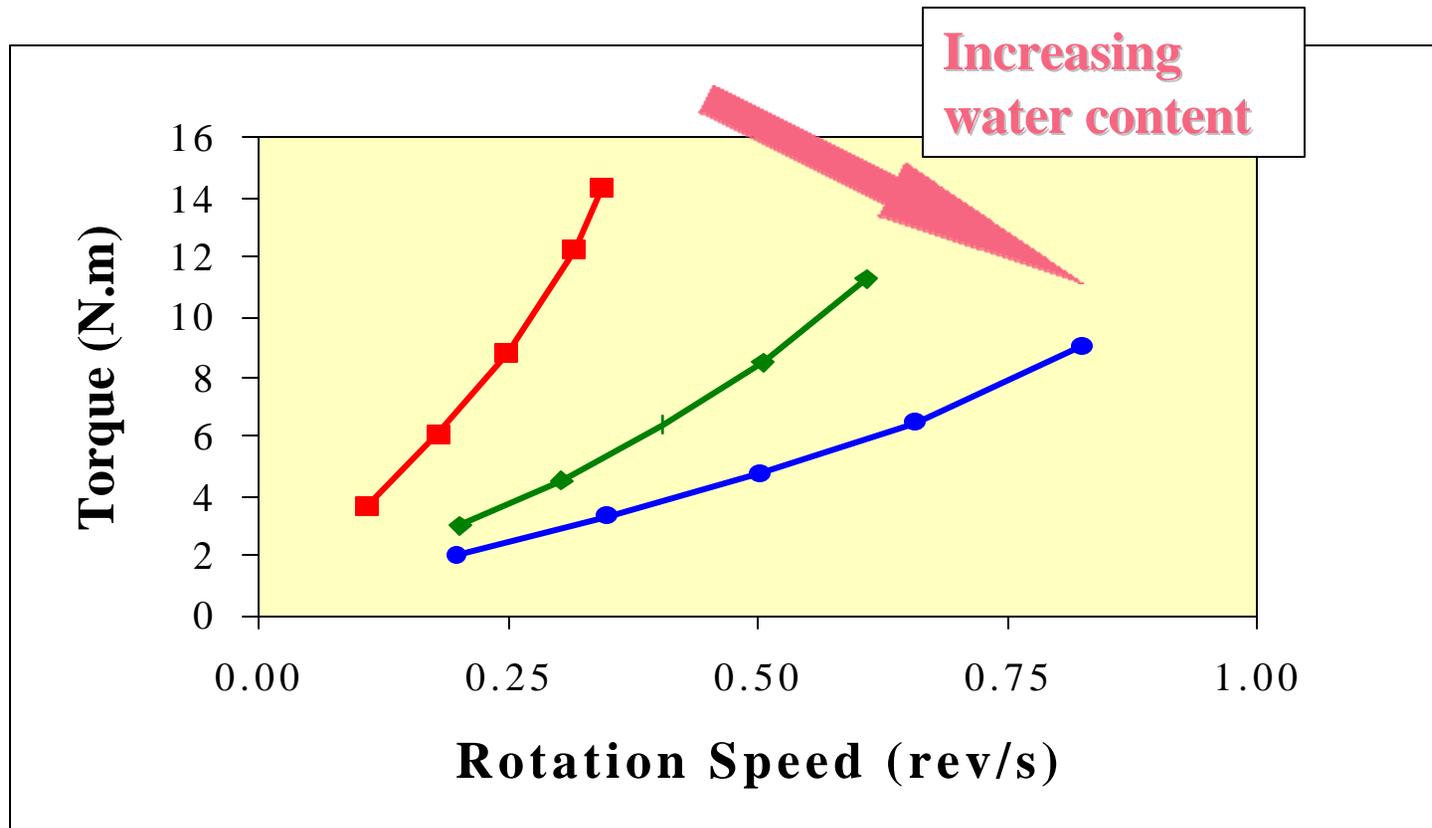
Same Plastic Viscosity
BUT
Different Yield Stress

Normal Strength Concrete



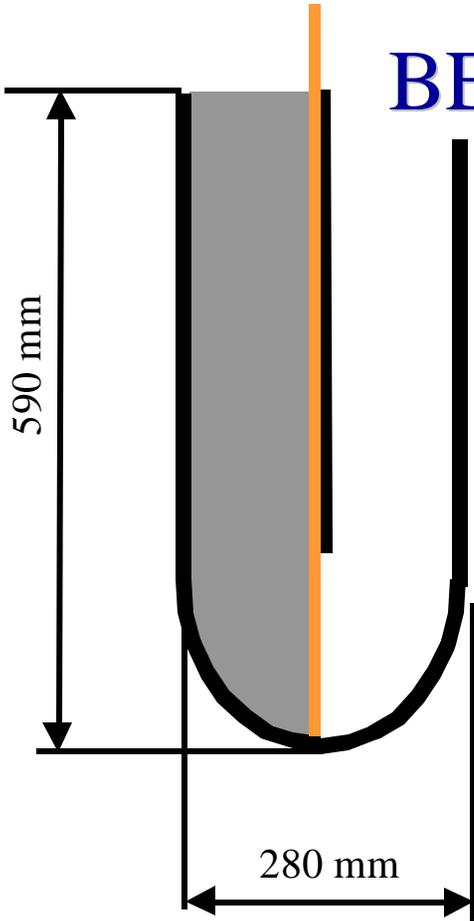
Ferraris, de Larrard , 1998

Self-compacting concrete

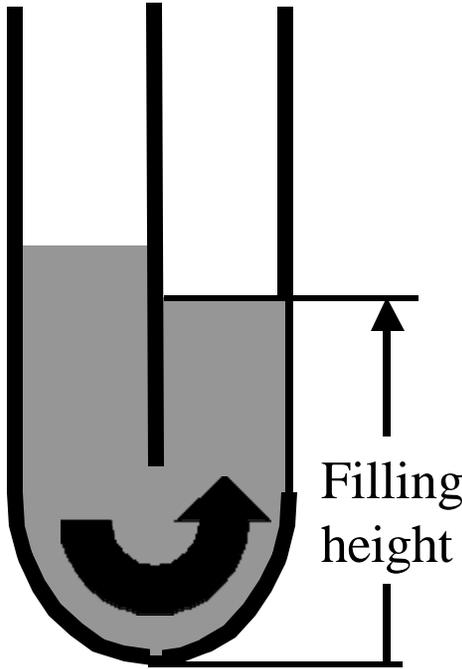


Ferraris, de Larrard , 1998

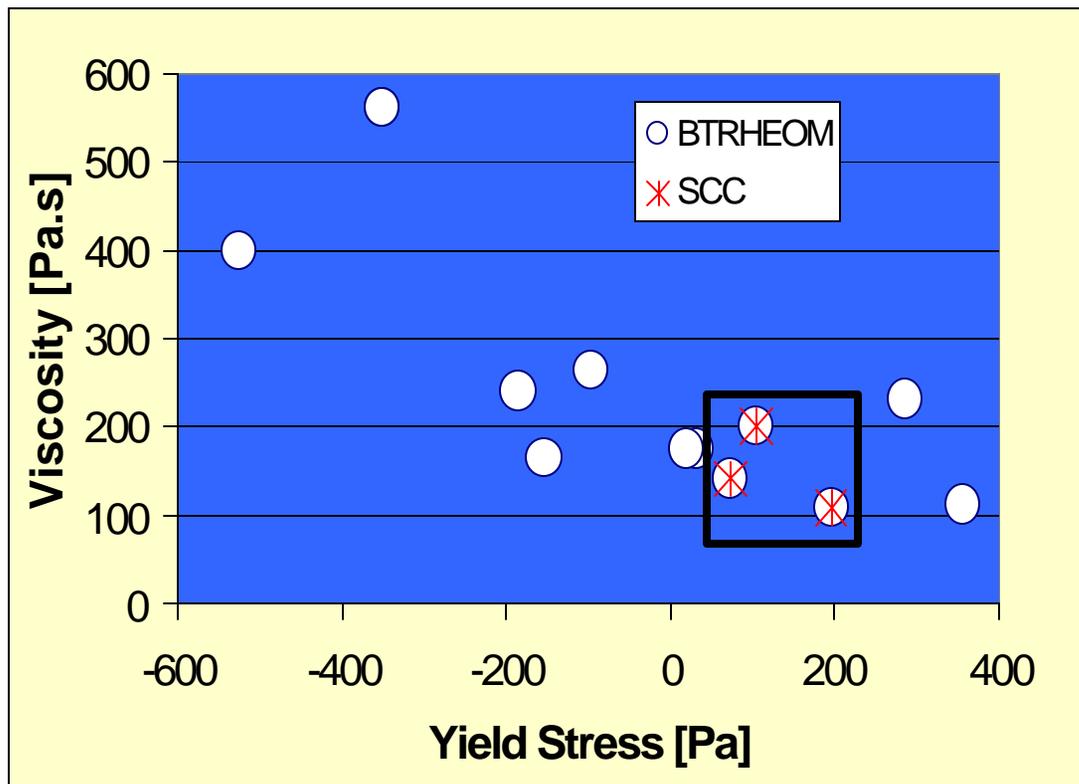
Filling test



AFTER



Workability Box for SCC (Beauprè)



Slump = 273 ± 13 mm
(5%)

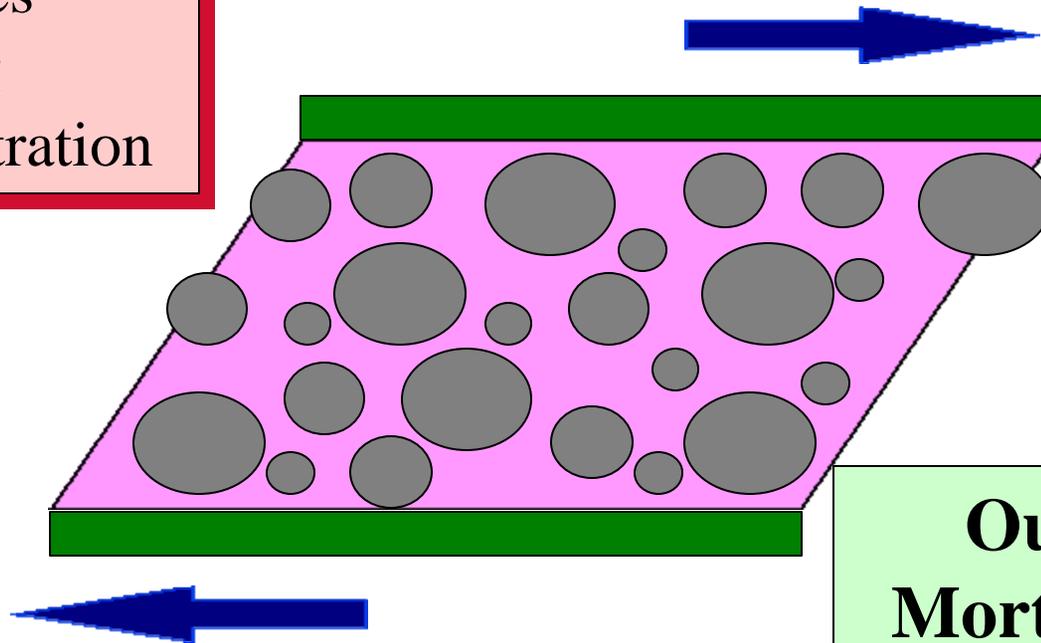
Spread = 655 ± 39 mm
(6%)

Ferraris, Brower, Ozyildirim, Daczko, 2000

Input

- Cement Paste
 - Viscosity
 - Yield stress
- Aggregates
 - grading
 - concentration

Rheology



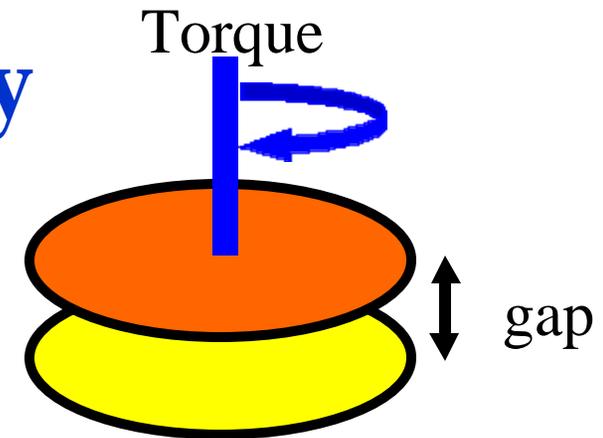
Output

Mortar/concrete

- Viscosity
- Yield stress

Cement Paste Rheology

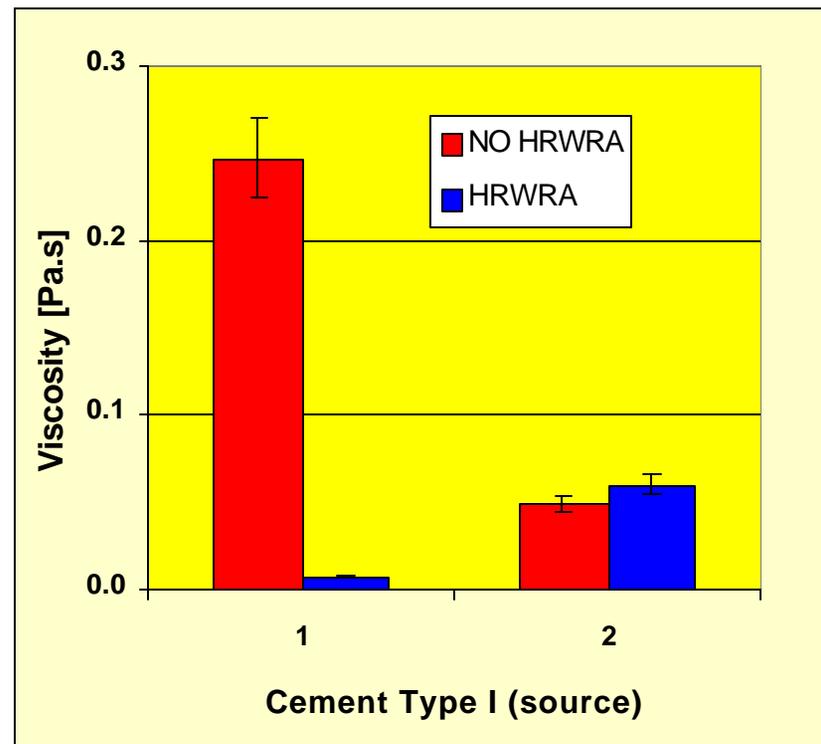
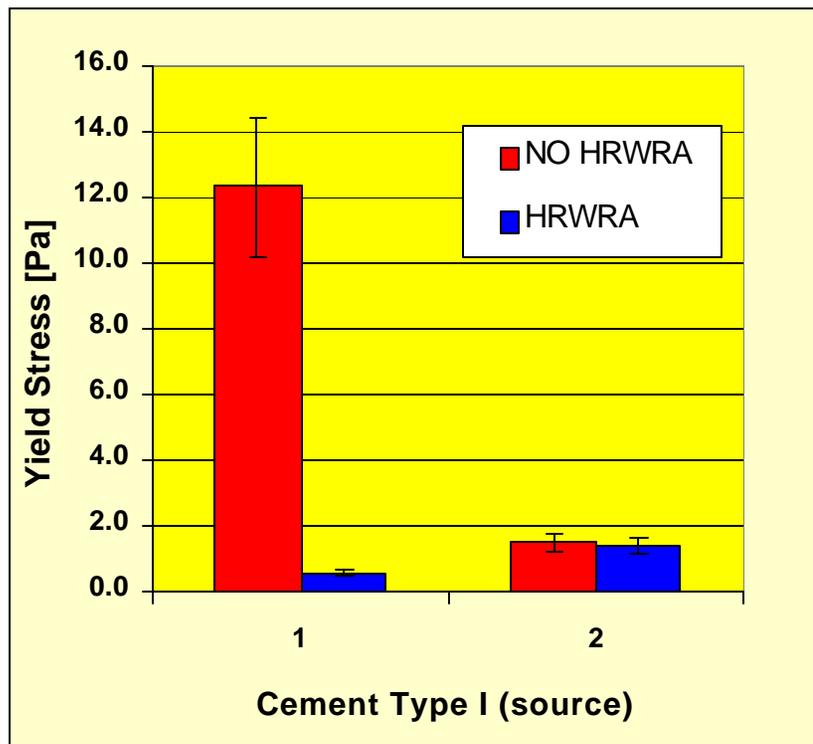
- Parallel Plate Rheometer
 - Same gap as in Concrete
- Mixer Type: PCA/CTL Method
 - Same shear rate as in concrete
- Temperature Controlled during mixing
 - Same temperature as in concrete: 20-23 C after mixing



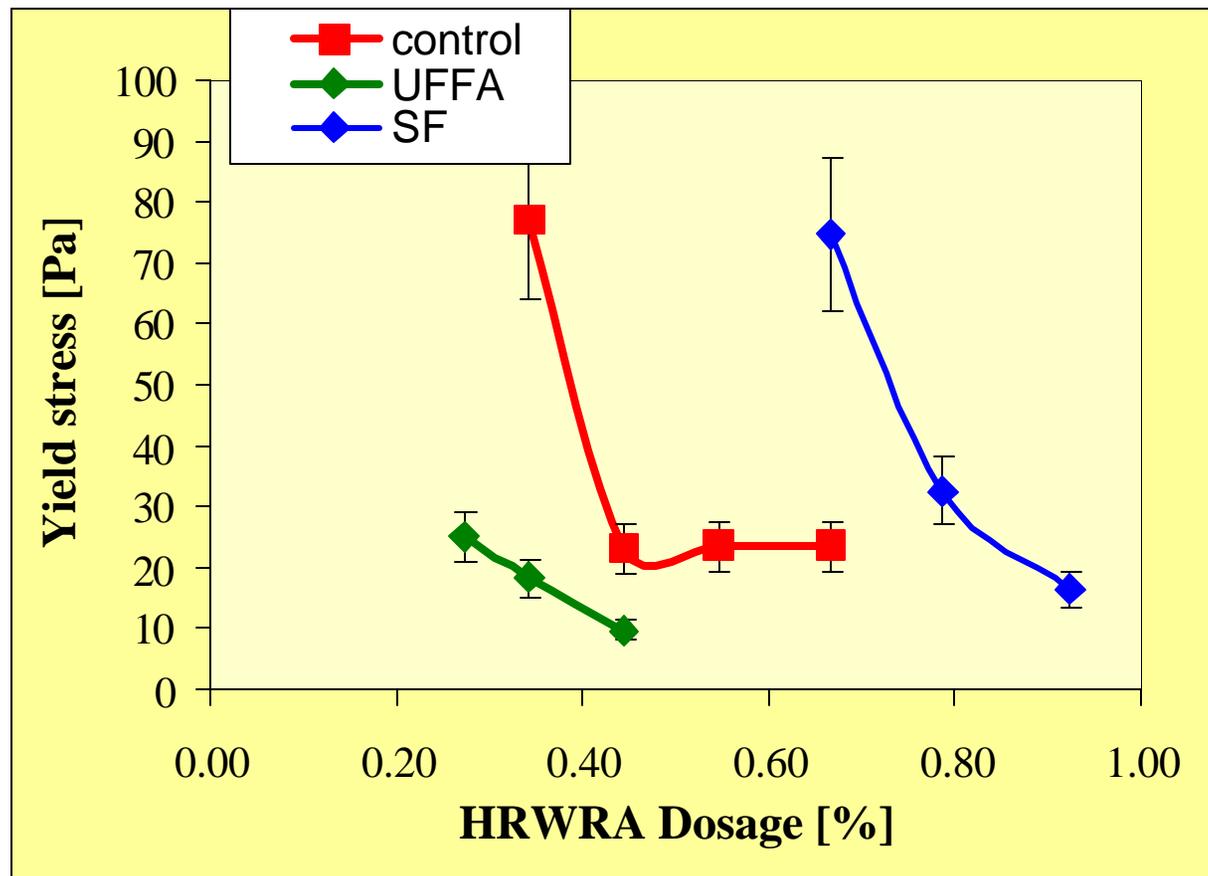
Application to Admixtures

- Predict concrete workability from the cement paste measurements
- Influence of mineral and chemical admixtures on workability
- Determine cement compatibility with chemical or mineral admixtures

Type of cement

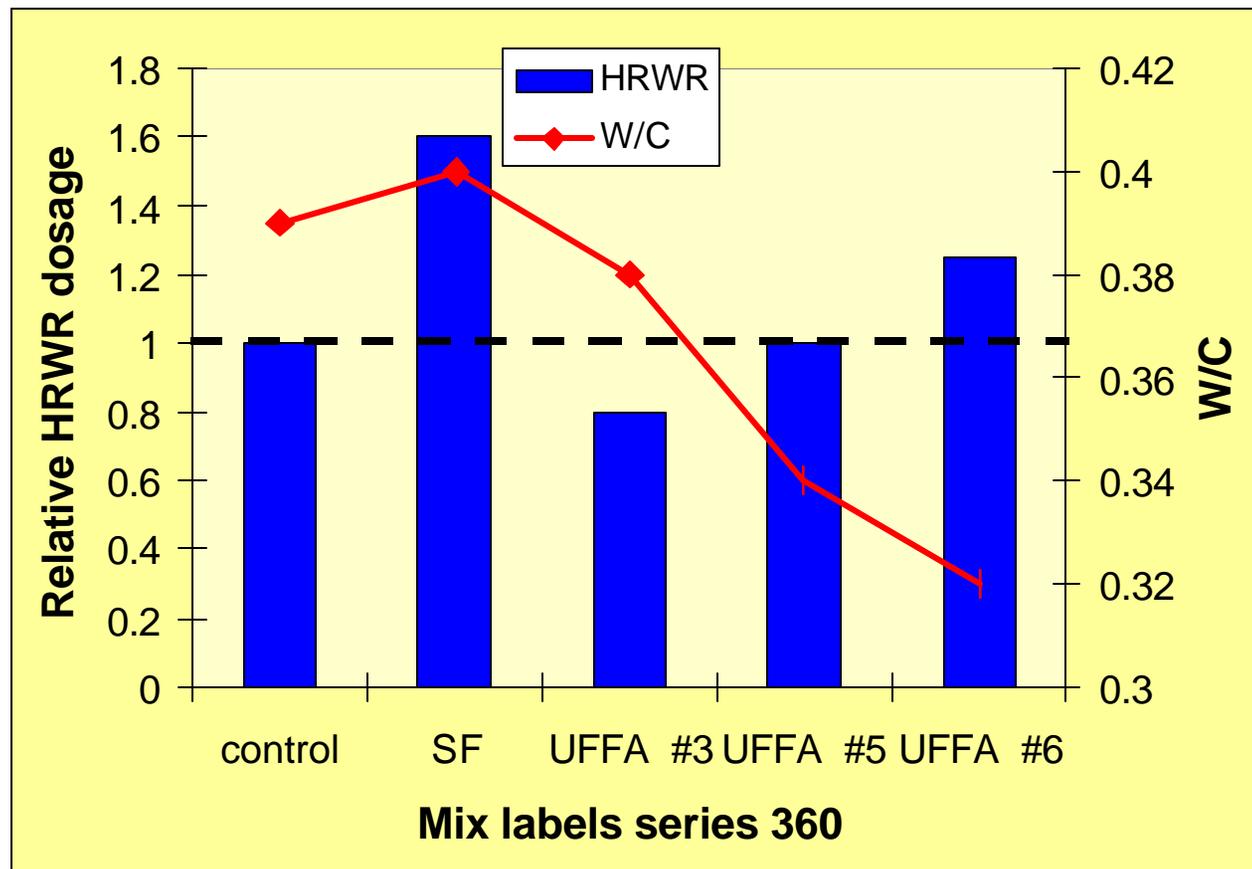


SF or FA in cement paste



Ferraris, Obla, Hill, 2000

SF or FA in concrete



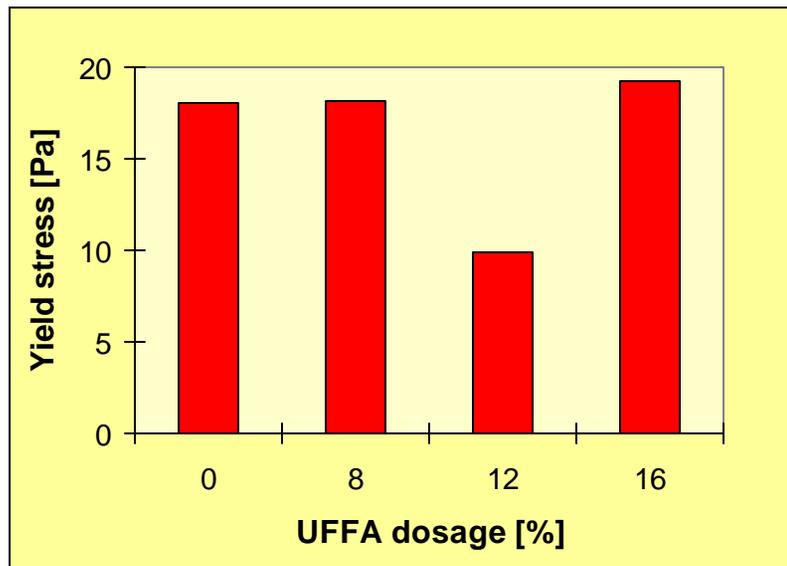
Ferraris, Obla, Hill 2000



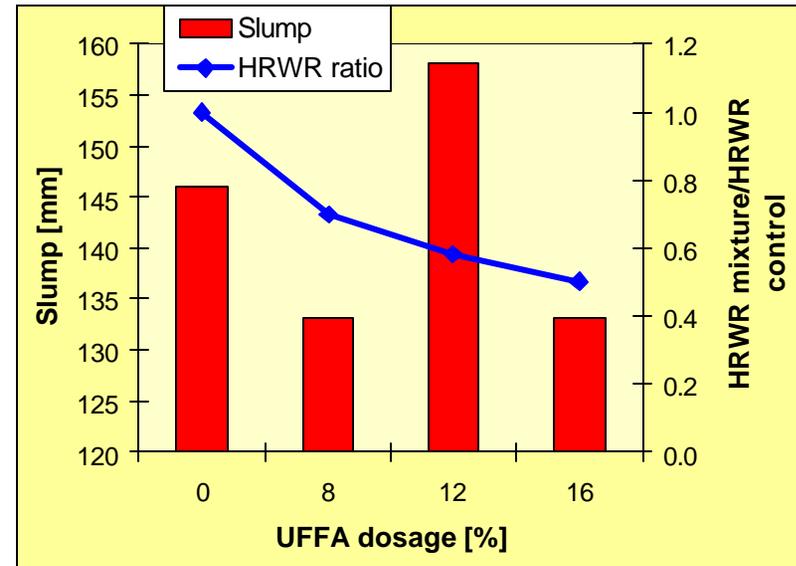
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Dosage of FA



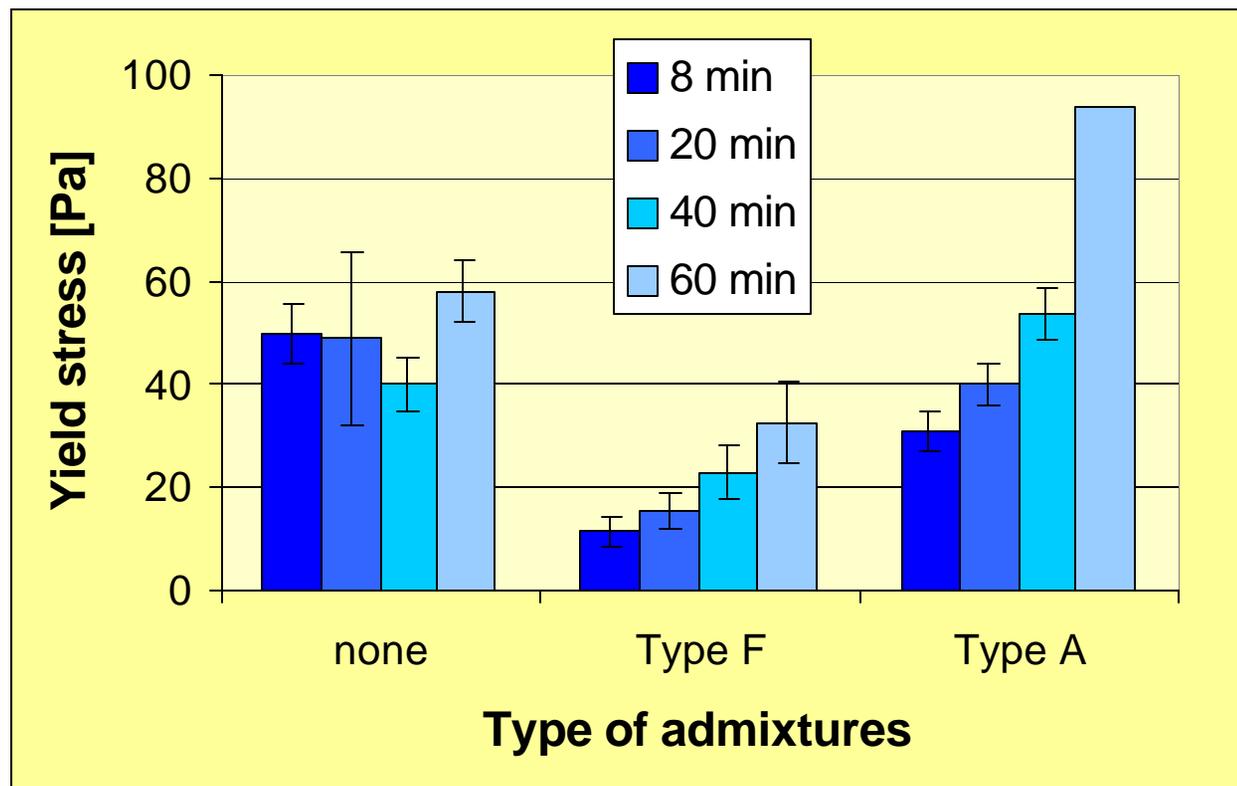
Cement paste



Concrete

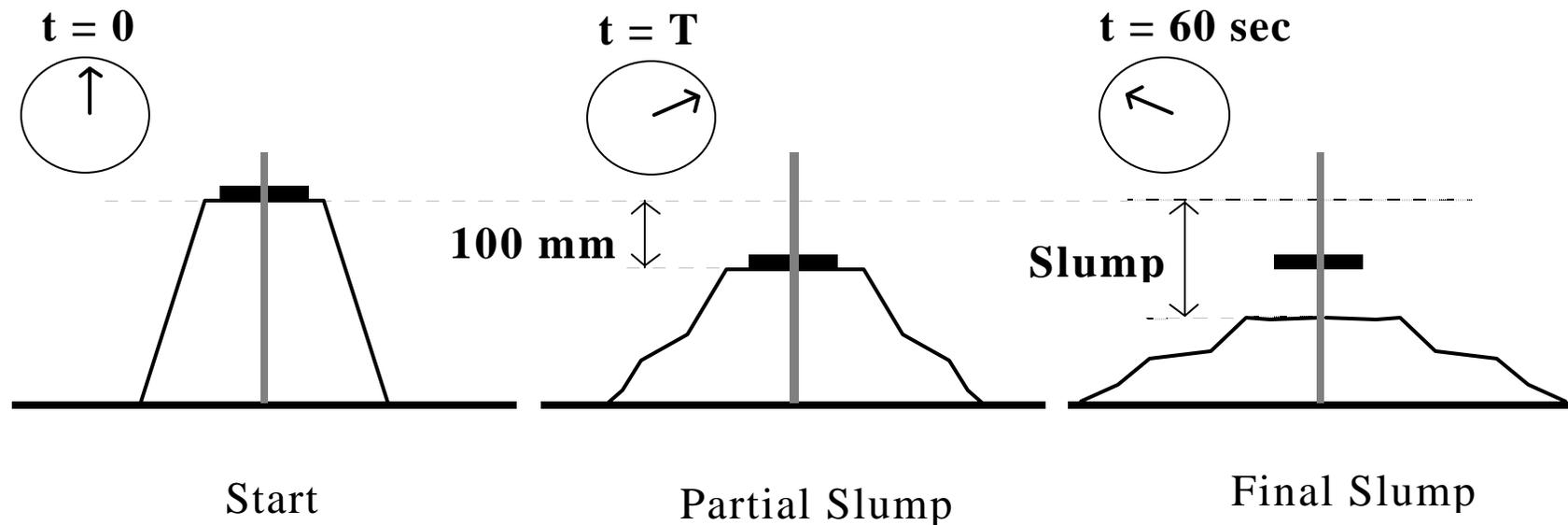
Ferraris, Obla, Hill , 2000

Slump Loss



Modified Slump Test

Rate at which the concrete slumps



Ferraris, de Larrard , 1998

Collaboration with ACI 236A

- “Workability of Fresh Concrete”
 - Chairperson: Chiara F. Ferraris, NIST
 - Secretary: Lynn Brower, MBT
- Scope:
 - Comparison of Concrete rheometers
 - State-of the art report on rheology
 - Guidelines for designing concrete with the rheological performance

Concrete Rheometers

- Type of rheometers
 - Two rheometers in fundamental units
 - Three rheometers in torque/rotational speed
- Results not related because of the different geometries
- Difficult interpretation

Future work

- Develop method to screen chemical admixtures
- Complete the model and
- Link between the rheology and the fresh concrete properties (finishability, placement,...)
- Better understanding of SCC rheological properties